

## Public Review Comment Metric

<b>Originating Office:</b> AIR-6B0	<b>Document Description:</b> TSO C210 Airborne Head Up Display (HUD)	<b>Project Lead/Reviewer</b> Richard Adler	<b>Reviewing Office:</b>	<b>Date of Review:</b>
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	Commenter	Section # and Page #	Comment	Suggested Change and Rationale	Disposition
1.	THALES Avionics	3.b, Page 1	HUD minimum failure condition classification is major while there is no minimum classification in ETSO-C210 currently under review	Where FAA TSO C210 requires a MAJOR minimum failure condition classification whatever intended function can be, EASA ETSO C210 (under consultation per NPA 2017-08) does not requires minimum failure condition classification as it will depend of the HUD intended function. Thales agrees with EASA proposal to not require minimum failure condition classification in ETSO/TSO, and considers that in perspective of EU/US harmonization, this should be consolidated with EASA, ETSO C210 being also under consultation. <i>Suggested change to: “The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft”.</i>	Accepted. TSO and ETSO documents have been harmonized: <b><u>b. Failure Condition Classifications.</u></b> <i>There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classifications for which the equipment is designed, keeping in mind obstructions to the pilot’s field of view resulting from potential malfunction conditions.</i>

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2.	Rockwell Collins	3.a, Page 1	Functionality – HUD TSO does not specifically call out type of aircraft (14 CFR Part) covered by the TSO.	Please consider providing additional clarification in this section since AS8055A specifically states that Part 27 and 29 may not be completely covered by the AS document requirements.	Not accepted. Additional performance requirements for Part 27 and Part 29 aircraft will need to be addressed at the airworthiness level.
3.	Rockwell Collins	3.b, Page 1	Failure Condition Classifications - HUD TSO establishes the minimum failure condition classification as Major, while the head-down classification is totally dependent on the intended function. The implication for this is the potential for blocking the pilot's field of view.	Please provide additional clarification or justification regarding the usage of "Major" as the only failure condition classification cited.	Accepted. TSO language has been revised as follows: <b><u>b. Failure Condition Classifications.</u></b> <i>There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classifications for which the equipment is designed, keeping in</i>

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					<i>mind obstructions to the pilot's field of view resulting from potential malfunction conditions.</i>
4.	Rockwell Collins	3.e, Page 2	TSO states development of software and complex custom electronic hardware to at least the level consistent with the failure condition classification defined in paragraph 3.b of this TSO. The concern is that wording could foster an interpretation that all software and complex custom hardware in a system would need to be developed to the DAL corresponding to the most severe hazard classification for the system.	As written, Sec 3.e. needs further clarification. Currently, reductions from the nominal DAL are allowed by DO-178 (revs B & C), DO-254, and other applicable means of compliance such as ARP4754A based on fault mitigation provided by system architectural design considerations. Use of DAL reductions is common in many of today's HUD systems. The wording of the TSO should make it clear that such reductions are allowed. One option would be to add the wording "except where otherwise justified by the safety assessment process" to the end of the sentence. Another option would be to modify a portion of the sentence to read something like:	Partially accepted. The revised 3.b language allows for classifications <i>appropriate for the equipment and dependent on the intended use of the equipment.</i>

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				“Develop the ... according to RTCA, Inc. document ..., to the ... level or levels (where reduction is justified by the safety assessment process) appropriate for the failure condition classification defined in paragraph 3.b of this TSO”.	
5.	Rockwell Collins	3.f, Page 2	Same Comment as Line 3	Same Comment as Line 3	Same disposition as Line 3.
6.	Garmin	3.a. Page 1	<p>No clear lines are drawn between conformal and non-conformal HUD embodiments. SAE AS8055A is specifically geared towards conformal HUDs that require a high level of symbol and boresight accuracy. A conformal HUD can have non-conformal symbology, which AS8055A refers to. An entirely non-conformal HUD may be subject to the below arguments:</p> <p>Example: Can a non-conformal HUD show a Zero Pitch (Horizon) line that is outside of the 5 Milliradian boresight tolerance requirements?</p>	Suggest a list of items that shall not be shown in a non-conformal HUD, which may include anything intended to show alignment to an outside entity, reference or orientation. A non-conformal HUD may show only fixed symbology and information.	Not accepted. The FAA acknowledges that SAE AS 8055A covers both conformal and non-conformal HUDs, but many performance requirements are geared specifically towards conformal HUDs. The FAA is willing to participate in an industry consensus standards development effort specifically geared towards non-conformal HUDs, however we are not modifying the SAE

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			<ul style="list-style-type: none"> <li>Image distance requirements in AS8055A (4.2.10) are defined based on collimation (image projected to infinity). This is limited by parallax convergence requirements of 3.5 Milliradians, equating to an image distance no closer than ~18 meters. A new, non-conformal HUD, (being submitted for TSO) may argue the need for conformal accuracy is not present. Thus, the need for collimated imagery, related accuracy and parallax requirements, do not need to be met. Further separation of AS8055A conformal HUDs and Non-conformal HUD embodiments is needed.</li> </ul> <p>Portions of AS8055 state inaccuracies shall not be “hazardously misleading” leaving the amount of inaccuracy open for subjective interpretation and inconsistent implementations, as in:</p>		AS 8055A specifications as part of this TSO effort.

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			<ul style="list-style-type: none"> <li>4.2.3 Boresight Aim: The AS8055A 5.0 milliradian bore sight requirement is not applicable to a Non-conformal HUD, since there is no “conformal” reference that the HUD is being aligned to. Can a non-conformal HUD project the image into the sun visor and cowl of the airplane? Is the boresight requirement always based on horizon (Zero pitch), zero yaw and zero roll? Is this necessary if the HUD is non-conformal?</li> <li>4.4.3 Combiner “out of alignment” warning: Specific angular limits are not defined in AS8055A. A non-conformal HUD would not need to meet this requirement, since there is nothing to align or align to, thus the image cannot become hazardously misaligned.</li> <li>5.8.a. Vibration: Collimated (conformal/infinity focused) HUDs have a characteristic of natural image stabilization. Thus,</li> </ul>		

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			in terms of vibration mitigation, it is best for a HUD to be focused at infinity. AS8055A states only “shall not be misleading or erroneous” which is again open for subjective interpretation and inconsistent industry implementations.		
7.	Garmin	3.b. Page 1	The paragraph does not align with the suggested text in paragraph 3.b. of the TSO Template in Order 8150.1D Appendix G. The paragraph utilizes both alternatives by requiring a minimum failure condition as well as providing guidance that the failure condition is installation dependent.	<p>Suggest changing to the alternate wording identified in paragraph 3.b. of the TSO Template in Order 8150.1D Appendix G.</p> <p>At a minimum, suggest aligning the following text to include the emphasized “and” instead of “or” as identified in the TSO Template in Order 8150.1D Appendix G.</p> <p>Document the loss of function and malfunction failure condition classification for which the equipment is designed.</p>	Accepted. Paragraph 3.b language revised to remove minimum failure condition. “or” revised to “and”
8.	Garmin	3.e. Page 2	The paragraph references “AC 20-115C, Airborne Software Assurance, dated July 19, 2013”. AC 20-115C will soon be replaced by AC 20-115D.	Reference “AC 20-115C or later version”, or simply reference AC 20-115D.	Accepted. Revised to read “AC 20-115C,..., or latest revision.” This change will also be

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				A draft of A(M)C 20-115D, a follow-on version of AC 20-115C which will be harmonized with EASA's AMC, was recently released by EASA for public comment (ref. EASA NPA 2017-12), and the published AC 20-115D was originally planned for July 2017.	incorporated into the TSO template in appendix G of Order 8150.1D.
9.	Garmin	3.f Page 2	<p>Including this specific DO-254 reference is redundant to the rest of the paragraph in this section.</p> <p>For custom electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies.</p> <p>DO-254 makes it clear how to address "simple" custom airborne electronic hardware.</p>	Remove this reference to DO-254 Paragraph 1.6.	<p>Not Accepted.</p> <p>The intent of referencing DO-254 section 1.6 for simple custom devices in the template is to complement the previous template sentence which only addresses complex custom devices. The inclusion of section 1.6 ensures that the verification and configuration management processes required by DO-254 for simple devices are performed and the resulting data artifacts</p>



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					for these processes created.
10.	Garmin	5.a.(3) Page 3	The paragraph states to include the following statement: This article meets the minimum performance and quality control standards required by a technical standard order (TSO). Installation of this article requires separate approval. This text does not align with the text identified in the TSO Template in Order 8150.1D Appendix G.	Update to align with the text in the TSO Template in Order 8150.1D Appendix G:  This article meets the minimum requirements of {insert the TSO number and revision letter}. Installation of this article requires separate approval.	Accepted. Revised to: <i>“This article meets the minimum requirements of TSO-C210. Installation of this article requires separate approval.”</i>
11.	Garmin	5.f Page 4	Paragraph. 5.f includes the statement:  Identify functionality or performance contained in the article not evaluated under paragraph 3 of this TSO (that is, non-TSO functions). Non-TSO functions are accepted in parallel with the TSO authorization. For those non-TSO functions to be accepted, you must declare these functions and include the following information with your TSO application:  The GAMA 16-28 “Industry Recommendations on the Management	1) Remove “or performance” in accordance with the GAMA non-TSO function recommendations.  2) Update Order 8150.1D Appendix G paragraph 5.f in accordance with the GAMA recommendations.  Work with GAMA to address all the non-TSO function recommendations.	Accepted. Removed “or performance” as suggested.

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			of Non-Technical Standard Order Functions” Recommendation 2 recommended revising the Appendix G TSO template to remove “or performance” from the quoted paragraph 5.f statement to ensure non-TSO function definitions are “fully aligned with the original intended N8150.3 definition”. This recommendation was not followed when FAA Order 8150.1D was published.		
12.	Garmin	5.f.(5) and 5.f.(6) Page 5	<p>These sections state the following:</p> <p>(5) Test plans, analysis and results, as appropriate, to verify that performance of the hosting TSO article is not affected by the non-TSO function(s).</p> <p>(6) Test plans, analysis and results, as appropriate, to verify the function and performance of the non-TSO function(s) as described in paragraph 5.f.(1).</p> <p>The bolded text “and results” is not included in the TSO Template in Order 8150.1D Appendix G.</p>	Remove the text “and results” to align with the TSO Template in Order 8150.1D Appendix G.	Accepted. Removed “and results” as suggested.

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13.	Garmin	5.g. Page 4	This paragraph does not align with the TSO Template in Order 8150.1D Appendix G. Additionally section 5.h. in the TSO Template in Order 8150.1D Appendix G is not included in this TSO draft.	Align these sections of the TSO with the TSO Template in Order 8150.1D Appendix G.	Accepted. Added paragraph 5.h. "A description of your organization as required by 14 CFR § 21.605."
14.	Garmin	7. Page 6	<p>This paragraph does not include the following text in Section 7.c. in the TSO Template in Order 8150.1D Appendix G:</p> <p>c. If the article contains software, include one copy of the OPR summary.</p> <p>This is good because per Order 8150.1D Appendix G paragraph 7, the OPR summary is considered "furnished data" required to be provided to any "entity (such as an operator or repair station)" that is furnished "articles manufactured under this TSO". Operators and repair stations typically do not have the same capability as a TC/STC design approval holder to make an appropriate assessment of OPR effect. Consequently, it will only serve to cause confusion to require an OPR</p>	Remove paragraph 7.c from Order 8150.1D Appendix G or limit its scope so that the OPR summary only needs to be provided to TC/STC design approval holders.	Partially Accepted. Paragraph 7.c was modified as follows: <i>c. If the article contains software, include one copy of the Open Problem Report (OPR) summary to type certification, supplemental type certification, or amended type certification design approval holders.</i>

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			summary to be provided to operators and repair stations.  This same concern has been raised in the context of the FAA/EASA/Industry A(M)C 20-OPR discussions.		
15.	GAMA	3.b.	The statement regarding the minimum failure condition classification should more clearly state as to which type of failure condition is applicable.	<b>Is:</b> The minimum failure condition classification for this TSO is major. <b>Proposed:</b> The minimum classification for failure conditions regarding the loss of function or malfunction of the HUD with respect to this TSO is no less severe than Major.	Partially Accepted. Revised to read: <b><u>b. Failure Condition Classifications.</u></b> <i>There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classifications for which the equipment is designed, keeping in mind obstructions to the pilot's field of view</i>

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					<i>resulting from potential malfunction conditions.</i>
16.	GAMA	3.b.	<p>The text discusses “the failure condition classification for the equipment” as if there were a single such classification. Subsequently it splits that into consideration of loss of function and malfunction (which is correct) when discussing the documentation, but the attribution of “major” is open ended. However, equipment such as the HUD has many failure conditions, several of which are not Major.</p> <p>Our recommendation would be to rewrite this section clarifying that the total loss of HUD function should be considered at least [classification] and that erroneous and misleading HUD should be considered at least [classification]. These are significantly affected by application details (single versus dual HUD applications, HUD certified as PFD versus not).</p>	<p><i>Failure Condition Classifications. The minimum failure condition classification for total loss of HUD function is Minor. The minimum failure condition classification for misleading erroneous information on the HUD is Major. These minimum classifications may be appropriate for applications where conventional Primary Flight Displays (PFD) are permanently available for cross comparison with the HUD. The failure condition classifications appropriate for the equipment may be higher and will depend on the intended function of the equipment in a specific aircraft. Consideration of common cause failure modes should be made to support applications where HUD units are installed for both flight crew members. Document the loss of function and malfunction failure condition classifications for which the equipment is designed, keeping in mind obstructions to the pilot’s</i></p>	<p>Partially Accepted. Revised to read: <b><u>b. Failure Condition Classifications.</u></b> <i>There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classifications for which the equipment is designed, keeping in mind obstructions to the pilot’s field of view resulting from potential malfunction conditions.</i></p>

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				<i>field of view resulting from potential malfunction conditions.</i>	
17.	EASA	3.b Page 1	The suggestion of minimum classification to Major is found misleading and doesn't represent the current installations. EASA will follow the same approach than for C113a without recommending a minimum failure condition.	FAA should follow the same approach than for C113a without recommending a minimum failure condition.	Accepted. Revised to read: <b><u>b. Failure Condition Classifications.</u></b> <i>There is no standard minimum failure condition classification for this TSO. The failure condition classification appropriate for the equipment will depend on the intended use of the equipment in a specific aircraft. Document the loss of function and malfunction failure condition classifications for which the equipment is designed, keeping in mind obstructions to the pilot's field of view resulting from potential malfunction conditions.</i>

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18.	EASA	3.c Page 1	The concern from EASA would be that an applicant may not test the HUD function for a large number of requirements. Some requirements are installation dependent but could be tested with assumptions/ some defined cases by the TSO applicant. The TSO applicant should document what remains to be tested at installation together with the definition of the test procedures.	3. c. Functional Qualification. The manufacturer must define the appropriate tests to verify compliance to section 4 of SAE AS8055A. Some requirements of SAE AS 8055A section 4 are installation dependent and cannot be fully verified at TSO article level. When the manufacturer is not able to test the TSO article in conditions representative to the overall range of the intended installation cases: - the installation conditions in which the manufacturer has performed the test should be documented - the installation procedures required in Section 5.a(3) of this TSO must define the functional qualification required to ensure the installed performance meets AS 8055A.	Accepted. Revised to: <b>3. c. Functional Qualification.</b> <i>The manufacturer must define the appropriate tests to verify compliance to section 4 of SAE AS8055A. Some requirements of SAE AS 8055A section 4 are installation dependent and cannot be fully verified at the TSO article level. When the manufacturer is not able to test the TSO article in conditions representative of the overall range of the intended installation cases: - the installation conditions for which the manufacturer has performed testing must be documented. - the installation procedures required in Section 5.a(3) of this TSO must define the functional</i>

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					<i>qualification required to ensure the installed performance meets AS 8055A.</i>